How Does Product Design Affect the Acceptance and Success of Pedelecs and E-Bikes

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Where Will Design for Pedelecs and E-Bikes Go?

- **E-Bikes will drop their pedals!**
- **E-Bikes will become electric scooter-like vehicles!**
- **The Pedelec will be completely different from the bicycle and the motorcycle!**
- **Pedelecs are still in the beginning phases with designers and manufacturers!**
- **Pedelecs have the potential to solve many traffic and health problems and at the same time, they are also fun to ride!**

III. What is Good Design?

Design is the key to the heart of the customer.

In any market you will find that the successful products are those that are superior in design.

Design is often misinterpreted as a stylish plastic cover.

Truly good design makes products simpler to produce because they are well thought out, consist of less parts, and incorporate new materials and production methods.

Good design pays!

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The Pedelec and E-Bike Industry has to learn from other Industries and Designs!

Examples of Products That Have Become Archetypes of Different Product Groups.

Coca-Cola Bottle

Plate, fork, knife, spoon, Chopsticks

Mercedes S-Class Car

Bike with Diamond Frame

Vespa Scooter

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All these Products have this in common:

Their messages are simple to understand.

-What they are used for

-How to use them

-We own more than just the product, we also own the Image that comes with it.

-They can easily win our hearts

We work hard to obtain these products which we have fallen in love with!

Or more to the point, we need to attain the status these products almost certainly can guarantee us!

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What can we learn from the Car and Computer Industry !

- Customer group orientation
- Mocular design and thinking
- Understanding design directions earlier through historical knowledge and research
- Marketing and Active Image development

- Good Design is easy to produce, done in close coordination with the R&D, production engineers, suppliers of components and consultancies

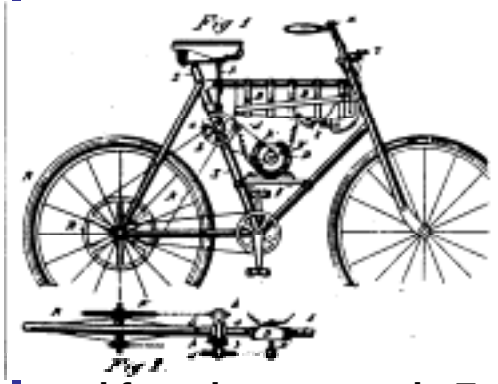
- Design is the process of guiding the inventors idea to a product which is accepted by the market!

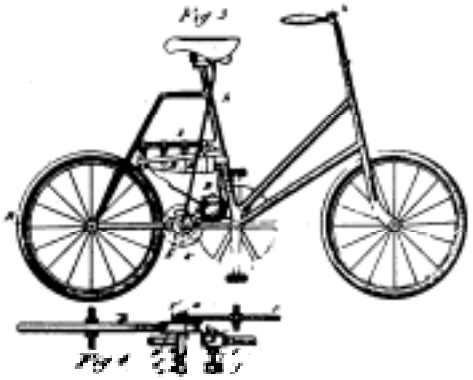
- Design makes customers pay for the same technical function more, because life is not rational!

V. Pedelec Design

Where Are We Now?

Comparison of Design Development Phases
Between the Automobile and the Pedelec/ E-Bike:





1771 **Nicolaus Joseph Cugnot, Steam powered french army truck, France**

1854 **Steam couch, Virgilio Bordino, Turin, Italy, 30 kg Koal per 100km**

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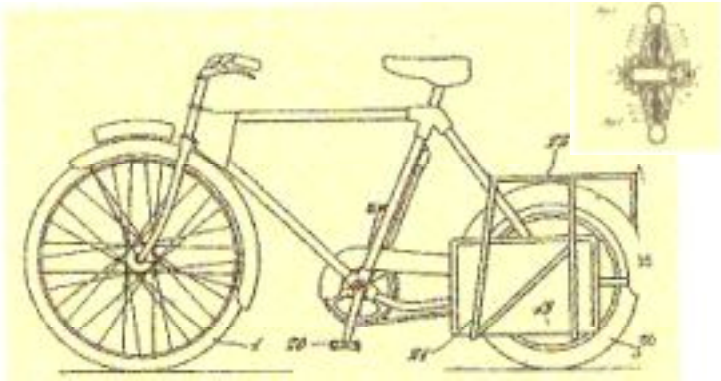
1875 **Siegfried Marcus Motorwagen, Wien, Austria**

1895 **Benz Hotelbus, Germany**



1895 **Benz, smal delivery truck, Germany**

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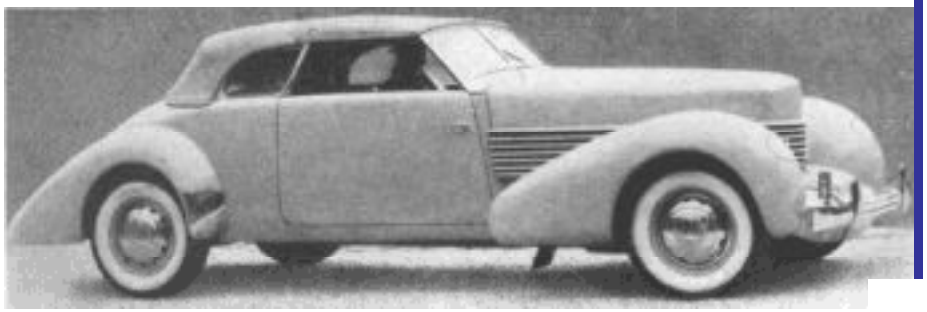
1900 **Lohner Porsche Electric, Wien, A**

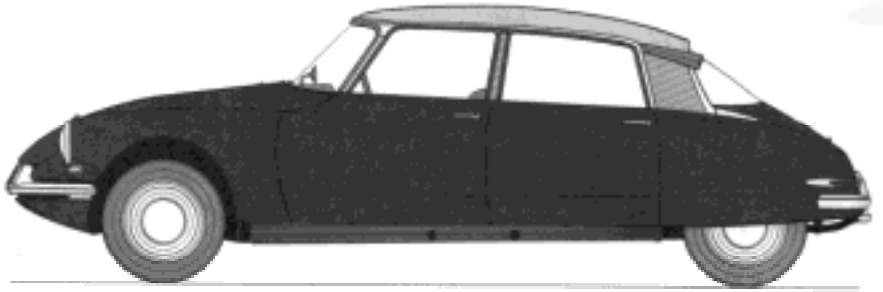
1908 **Ford Model T, USA advertisment (6398 pieces have been produced)**

1926 **Horch, Germany, 100km/h 60 PS**

1935 Early Beatle, Porsche, Germany



1937 Duesenberg, USA



1955 Citroen DS, France

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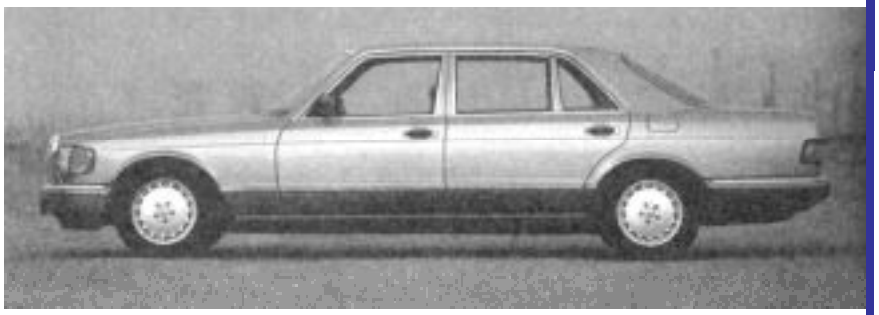
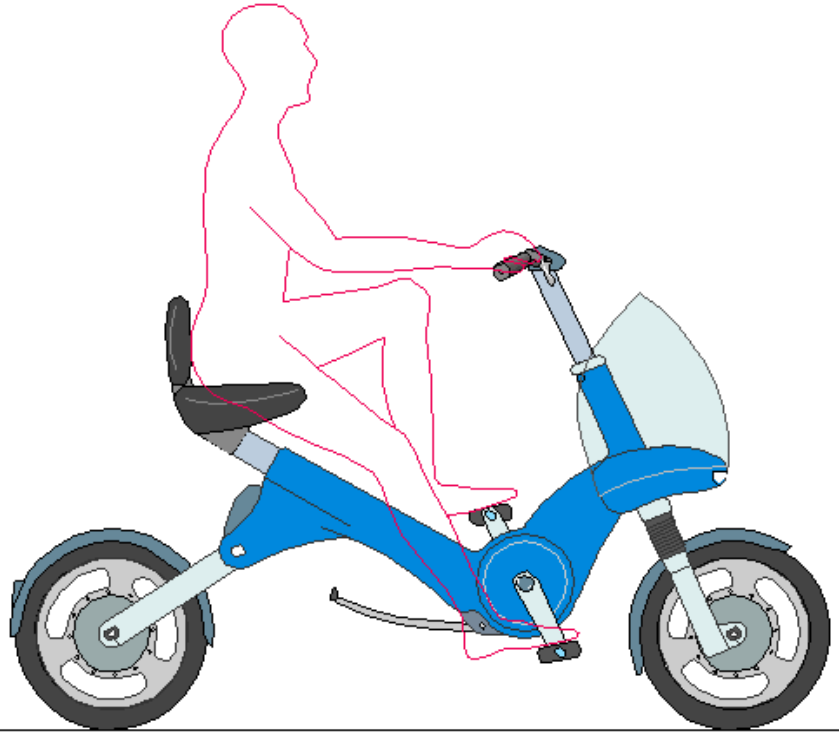
1957 Steyer Puch 500, Austria



1990 Mercedes-Benz S-Klass, Germany

1990 Renault Espace, France



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1990 Daihatsu Cuore, Japan

1995 TULIP by PSA, France

2001 Toyota Yaris, Japan

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1995 **ASIA MOTORS, Korea, Design Study**

2001 **AUDI A2, Germany**

The Pedelec of today is compared to the design history of automobiles at about the time of 1926 when their design was still based on the coach builders technology and style.

The Horch of 1926 still had wooden spokes and a wooden frame for the structure.

Obviously, the Pedelec industry, being in its early stages, still has a long way to go when it comes to creating an archetype Pedelec that is on the level of today's Cars.

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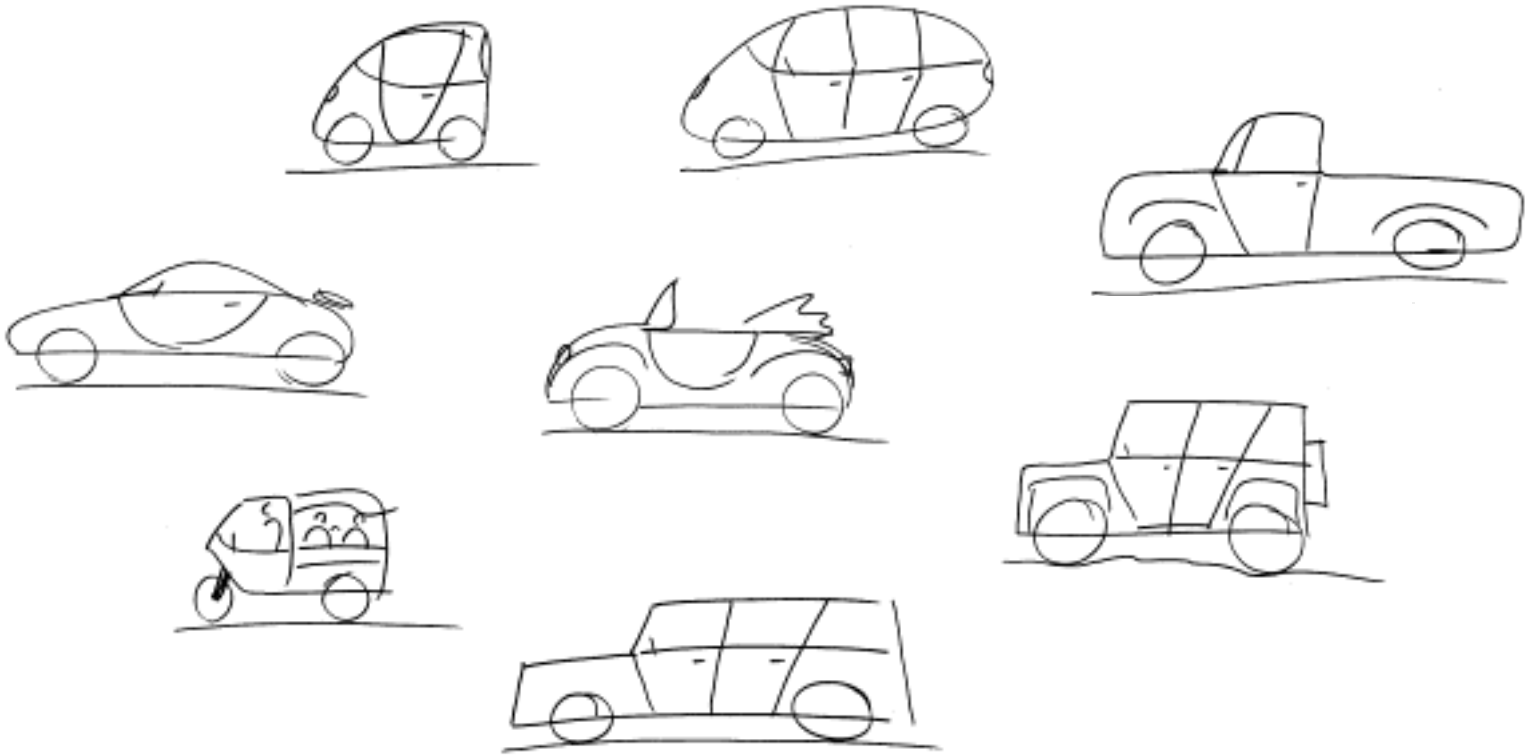
IV. The Archetype Automobile and the Subcategories Which Make it Suitable for Everyone!

The Pedelec needs comparable status and variety like the car to also be successful!



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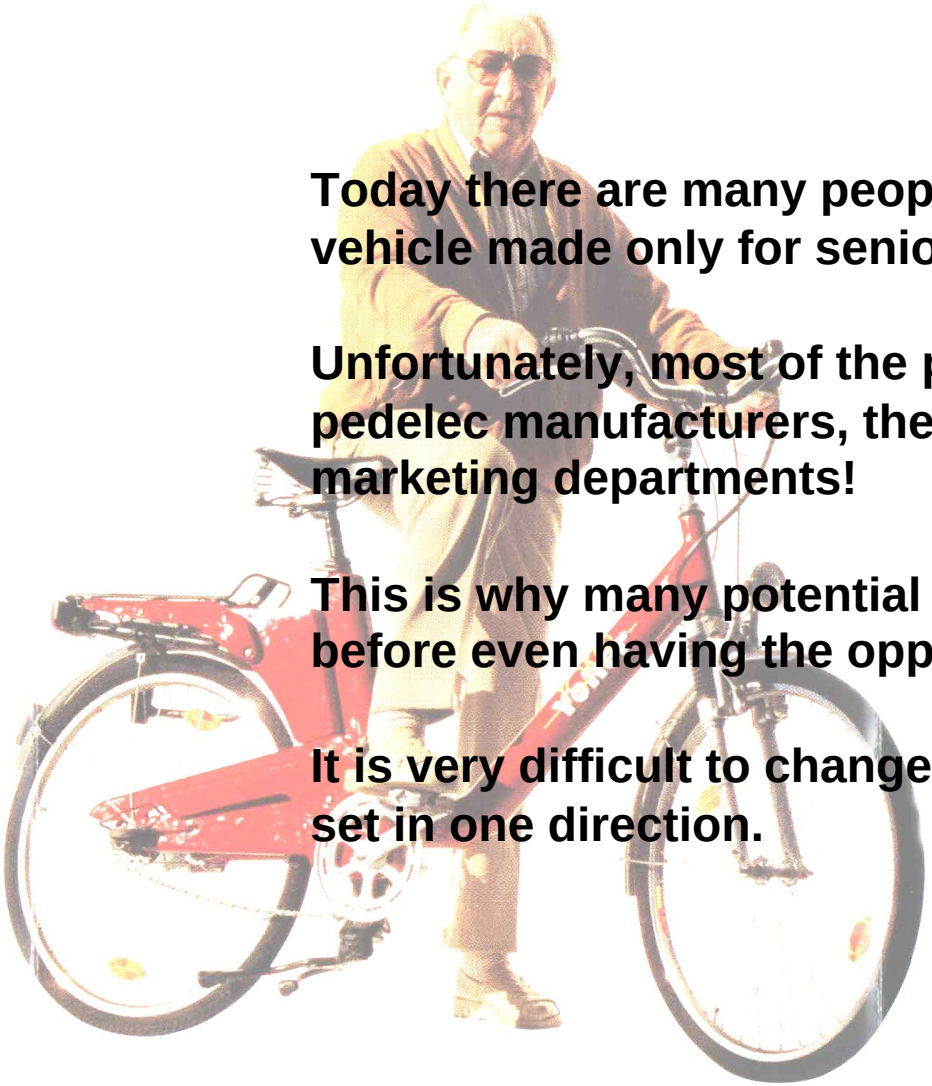
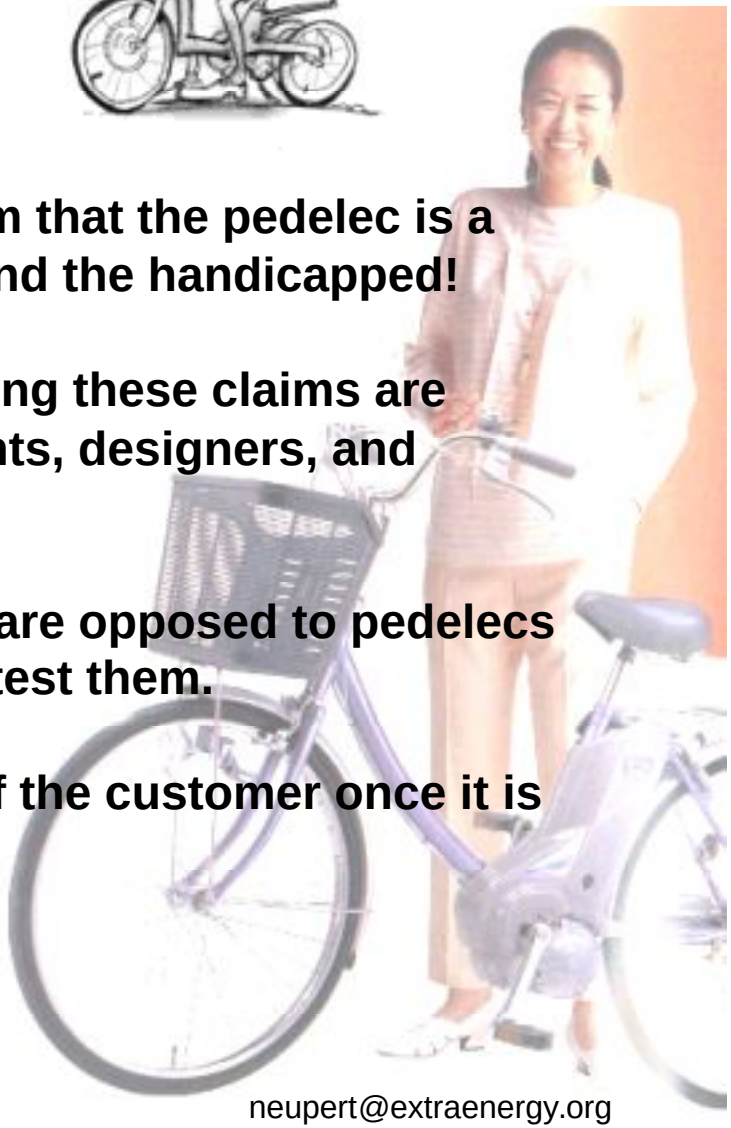
Minimum age 45? Or lets say 75!





Today there are many people who claim that the pedelec is a vehicle made only for senior citizens and the handicapped!

Unfortunately, most of the people making these claims are pedelec manufacturers, their consultants, designers, and marketing departments!

This is why many potential customers are opposed to pedelecs before even having the opportunity to test them.

It is very difficult to change the mind of the customer once it is set in one direction.

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VI. Customer Groups of Pedelecs Encompass Everyone!

(As soon as the variety of suitable designs is available!)

Touring

City / Comfort

Folding

Wellness

Exclusive

Racing

Utilit

Rehab

Commuting

Easy

Family

Sports

Safe against theft; Easy to lock; Theft deterrent (if lock is damaged from theft, bicycle will be inoperable); Full suspension; Electric non-dynamo lightnin
gravity; Safe upright position; Foldable; Lightweight; Grease free (at places where human contact occurs); Battery with included charger and cable; Mod
so that it can be easily adopted to different customer needs without high additional molding costs; Totally silent; Robust and long lasting; In case of mi
should be able to withstand scratches which lead it look bad; Easy to fit and lift to put in a car; adaptable lock; Protection from rain and dirt damage; Erg
variable handlebar positions; Adaptable comfortable and ergonomic seating positions; lockable luggage compartment for helmet and briefcase; etc.; Co
the riders range information calculated on the actual average consumption and also the energy left in the battery; Computer showing the riders speed, m
traveled, calories burned, etc.); Enough space and power to transport two kids and two boxes of mineral water; Enough power to make a 20 percent gra
problem; Safety features like ABS and Airbag; Routing assistance options, free speakers, and mounting hardware for cellular phones and radios; Solar
the surface recharging the batteries; recuperative braking as an automatic step of the mechanical brake system; Batteries that contain no poisonous ma
which have a lifetime of at least 1000 cycles and can be recharged in 5 minutes; batteries which are memory free; complete control of every feature by in
integrated in the handlebar; all wheel drive; battery easy to exchange; automatic plugs to connect the battery when placed in position; all cables covere
hanging around just held together by plastic clips; completely recyclable; easy to disassemble and separate; easy to take off the wheels even when they
stiff frame; mechanical shock resistant structure and electronics; available in sizes for extremely tall and extremely small persons; self explaining functi
to understand by any user without reading the instruction manual; good functioning in extremely cold and hot climates without damage; availability of s
used size and enough space to put them on; many accessory options such as baskets, racks, lights, and bags; a customized sturdy kickstand to hold th
bike; Comfortable; Lightweight; Easy to pedal; Able to freewheel; Easy to get on/off; Secure riding; Easy to go uphill; Technically unchallenging for the
free; Safe against theft; Easy to lock; Theft deterrent (if lock is damaged from theft, bicycle will be inoperable); Full suspension; Electric non-dynamo lig
of gravity; Safe upright position; Foldable; Lightweight; Grease free (at places where human contact occurs); Battery with included charger and cable; M
constructed so that it can be easily adopted to different customer needs without high additional molding costs; Totally silent; Robust and long lasting; I
accidents, bike should be able to withstand scratches which lead it look bad; Easy to fit and lift to put in a car; adaptable lock; Protection from rain and
Ergonomic and variable handlebar positions; Adaptable comfortable and ergonomic seating positions; lockable luggage compartment for helmet and br
Computer showing the riders range information calculated on the actual average consumption and also the energy left in the battery; Computer showing
miles/kilometers traveled, calories burned, etc.); Enough space and power to transport two kids and two boxes of mineral water; Enough power to make
gradient without any problem; Safety features like ABS and Airbag; Routing assistance options, free speakers, and mounting hardware for cellular phon
Solar Cells integrated in the surface recharging the batteries; recuperative braking as an automatic step of the mechanical brake system; Batteries that
poisonous materials; batteries which have a lifetime of at least 1000 cycles and can be recharged in 5 minutes; batteries which are memory free; comple
feature by instruments integrated in the handlebar; all wheel drive; battery easy to exchange; automatic plugs to connect the battery when placed in pos
covered; no cables hanging around just held together by plastic clips; completely recyclable; easy to disassemble and separate; easy to take off the wh
they have a hub motor; stiff frame; mechanical shock resistant structure and electronics; available in sizes for extremely tall and extremely small person
functions which are easy to understand by any user without reading the instruction manual; good functioning in extremely cold and hot climates withou
availability of spoke tires for the used size and enough space to put them on; many accessory options such as baskets, racks, lights, and bags; a custo
kickstand to hold the weight of the bike; Comfortable; Lightweight; Easy to pedal; Able to freewheel; Easy to get on/off; Secure riding; Easy to go uphill
unchallenging for the rider; Maintenance free; Safe against theft; Easy to lock; Theft deterrent (if lock is damaged from theft, bicycle will be inoperable);
Electric non-dynamo lighting; Low center of gravity; Safe upright position; Foldable; Lightweight; Grease free (at places where human contact occurs)
included charger and cable; Modularly constructed so that it can be easily adopted to different customer needs without high additional molding costs; T
Robust and long lasting; In case of minor accidents, bike should be able to withstand scratches which lead it look bad; Easy to fit and lift to put in a car;
Protection from rain and dirt damage; Ergonomic and variable handlebar positions; Adaptable comfortable and ergonomic seating positions; lockable lu
compartment for helmet and briefcase; etc.; Computer showing the riders range information calculated on the actual average consumption and also the
battery; Computer showing the riders speed, miles/kilometers traveled, calories burned, etc.); Enough space and power to transport two kids and two bo
water; Enough power to make a 20 percent gradient without any problem; Safety features like ABS and Airbag; Routing assistance options, free speaker
hardware for cellular phones and radios; Solar Cells integrated in the surface recharging the batteries; recuperative braking as an automatic step of the
system; Batteries that contain no poisonous materials; batteries which have a lifetime of at least 1000 cycles and can be recharged in 5 minutes; batteri
memory free; complete control of every feature by instruments integrated in the handlebar; all wheel drive; battery easy to exchange; automatic plugs to
battery when placed in position; all cables covered; no cables hanging around just held together by plastic clips; completely recyclable; easy to disasse
easy to take off the wheels even when they have a hub motor; stiff frame; mechanical shock resistant structure and electronics; available in sizes for ext

VII: Design Goals to Create a Successful Pedelec Product!

B. Design Aspects for a Pedelec Based on the Diamond Frame Geometry

Although it is not certain that the diamond frame geometry will continue to be dominant in the future, it can be used to explain the correct position of every component that is the basis for a good design.

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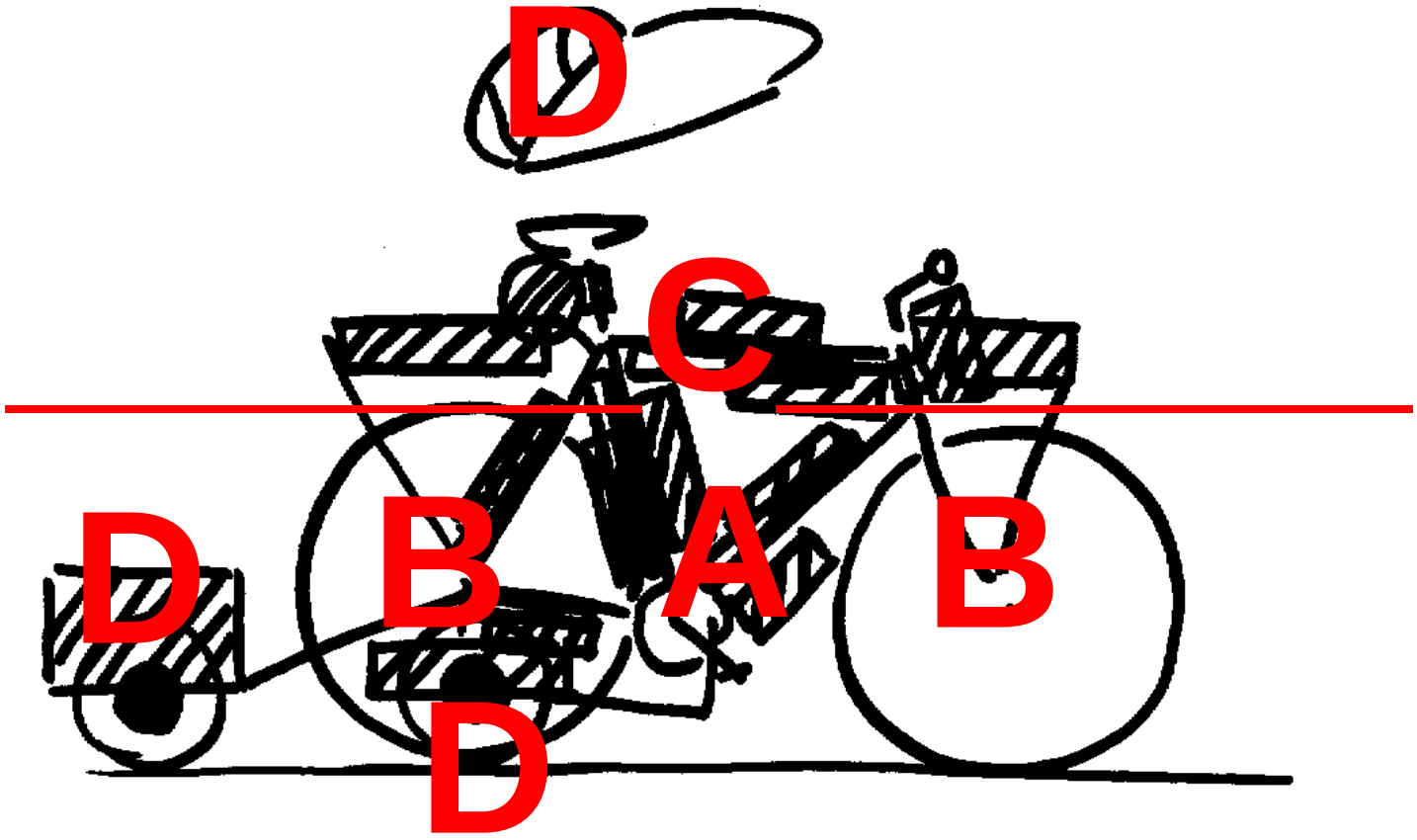
C. Where to Put the Batteries?

When considering all of the possible positions, I have determined that there are 4 zones capable of containing a battery.

A B C and D for others. The zone differences are mainly connected with the weight distribution and the stability at high speeds.



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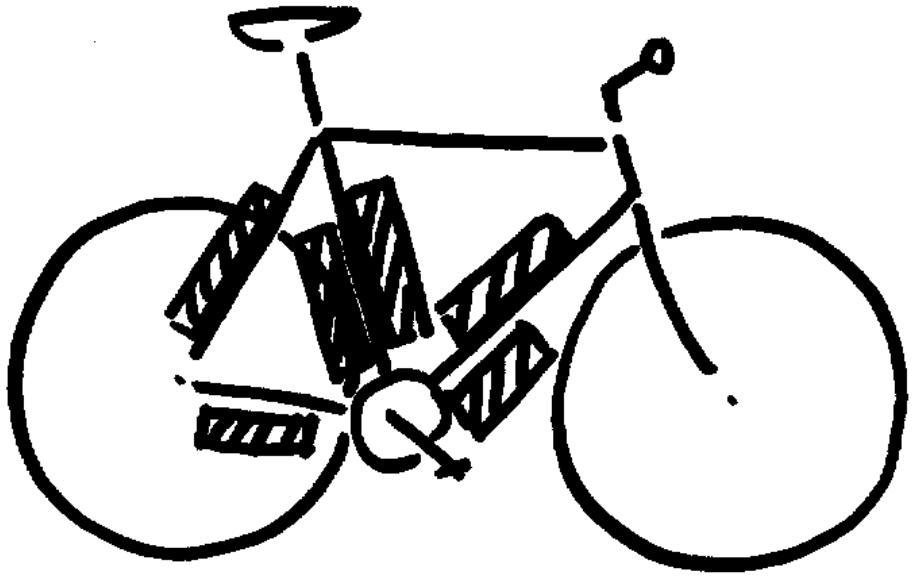
D. Detailed View on 9 Battery Positions!

1 – A and B: Batteries mounted on the frame tubes

+ stable and low center of gravity
+ easy to produce and easy to integrate in the design



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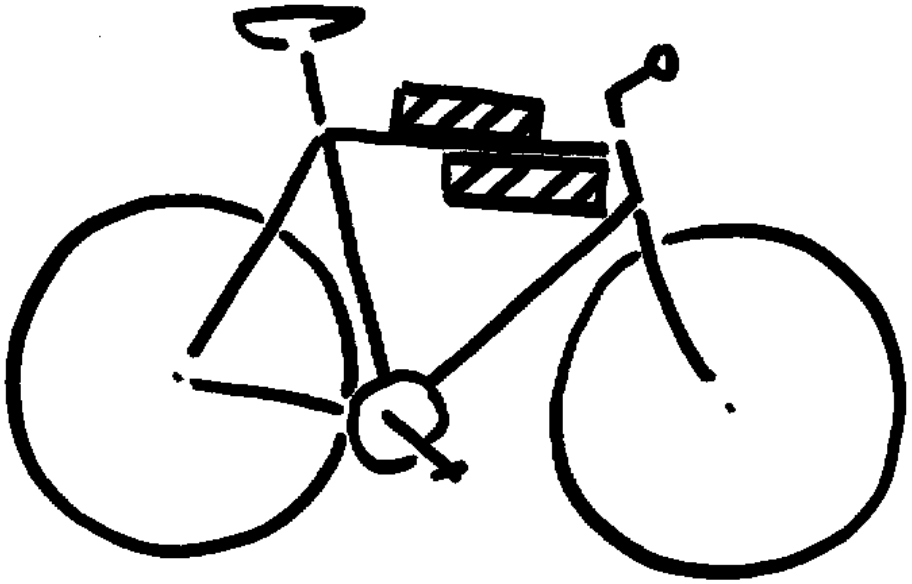
2 – C: Batteries mounted on the crossbar

+ easy to integrate human interface functions into the battery pack without additional connections

- high center of gravity



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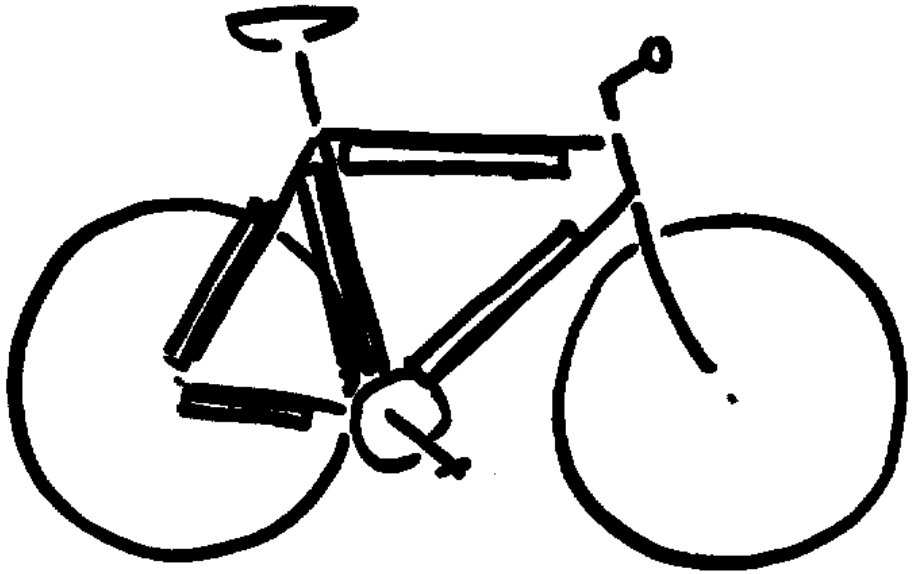
3 – A-B-C: Batteries in the frame tubes

+ safe place against demolition and theft
+ easy to integrate into the total design
- difficult to handle the in and out, if not specifically designed parts, such as the ones produced by Sony



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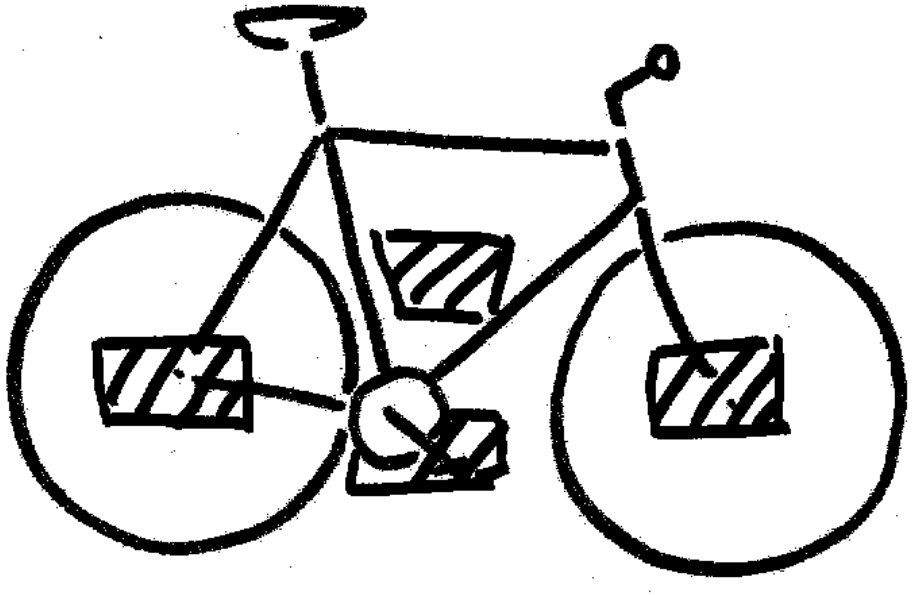
4 – A-B-C: Batteries held by carriers mounted on the frame or part of the frame

+ easy to produce
+ if well researched and planned, could be very good integrated into the design
- can catch a lot of dirt if mounted in certain positions (under the crank shaft) which is a problem when people carry their battery into the office to charge.



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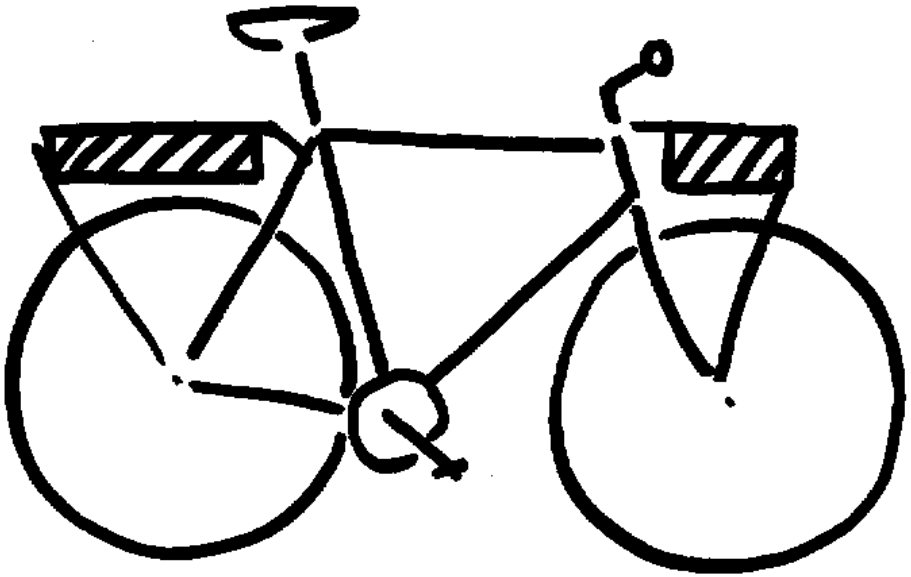
4 – C: Batteries mounted on or in the rear or front carrier

+ easy to produce
- heavy
- difficult to stand up
- dangerous vibrations occur at high riding speed



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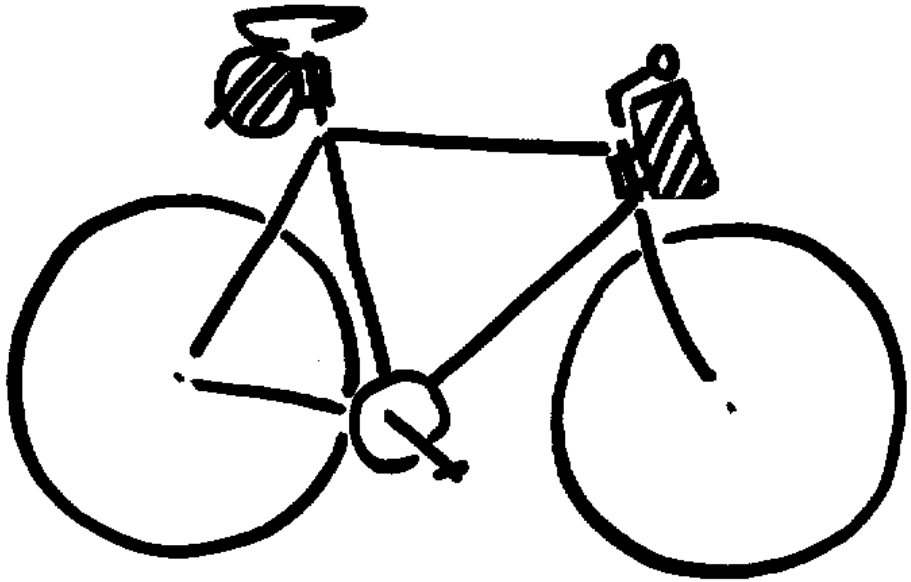
5 – C: Batteries mounted on the seat post and on the handlebar

+ easy to take on and off
+ easy to include the human interface functions
- high center of gravity
- difficult to make it safe against theft at the seat post



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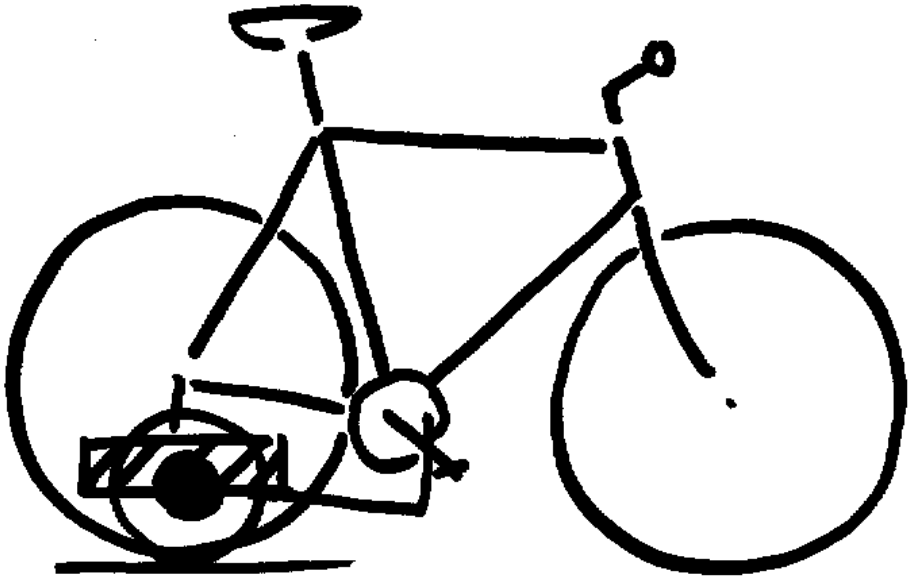
6 –C Others: Batteries in a side wagon

+ easy to put on any bike
- difficult to park bike
- difficult to lift into a car trunk



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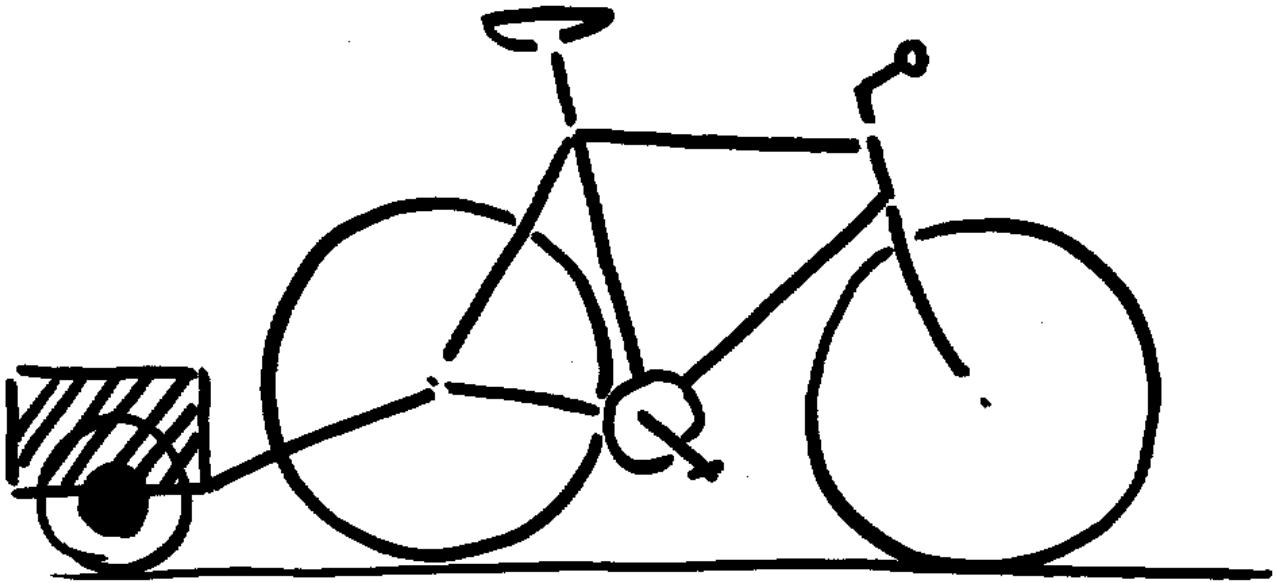
7 – C Others: Batteries in a trailer

+ easy to put on any bike
+ if the whole system (including the motor) is in the trailer and the trailer is just pushing itself and the load, it could be a very good system
- difficult to park bike
- difficult to lift into a car trunk



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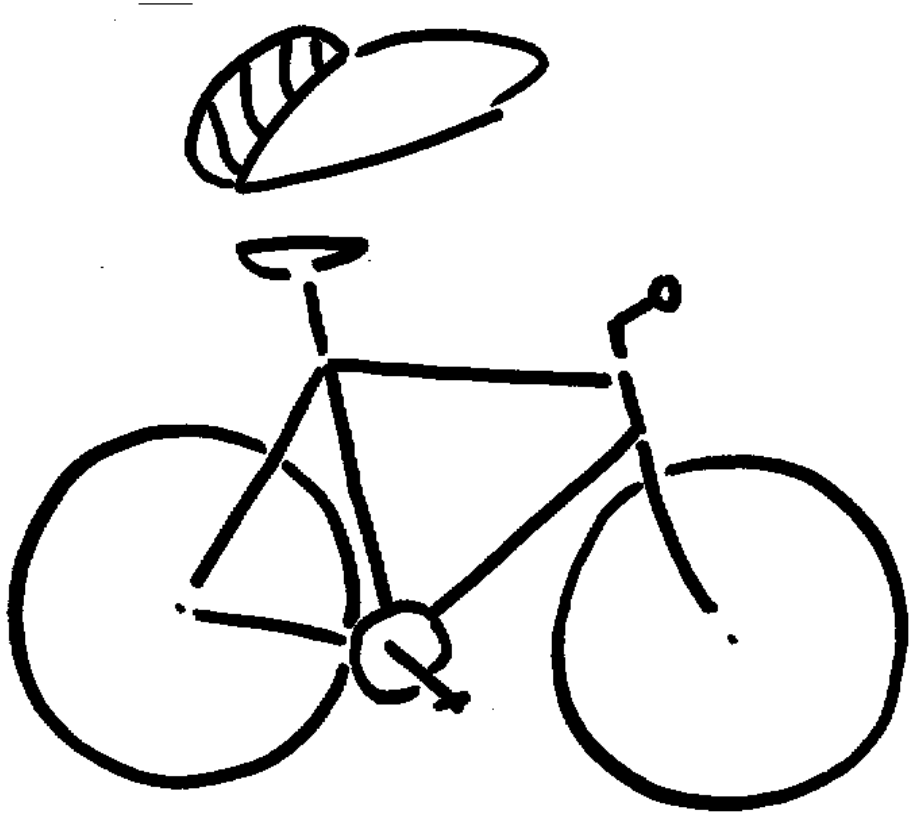
8 – C Others: Batteries on the Riders Body e.g. a bag pack

+ easy to put on any bike
+ easy to prevent theft
- tiring to rider because of added weight



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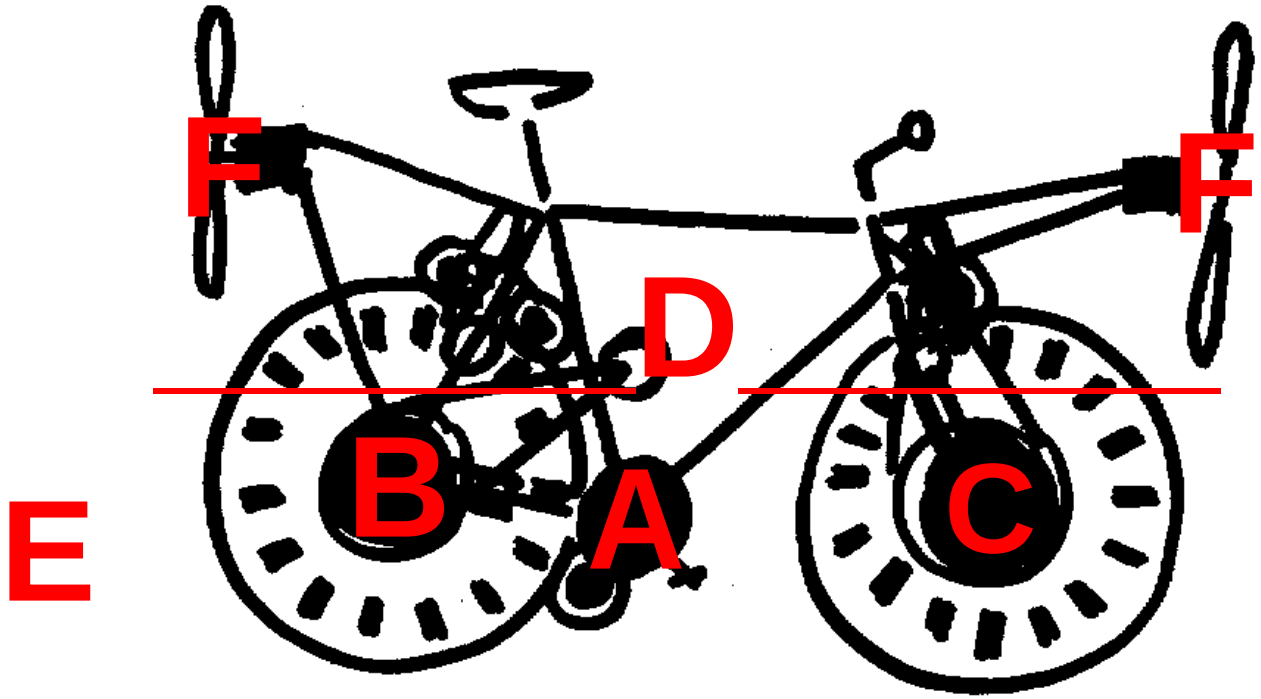
E. Where to Put the Motor?

It is quite interesting to study the history of motorcycles. It is most incredible to see that every possibility has already been attempted.

I grouped the possibilities I found into 11 Categories. If I were to get even more specific, I could have split these categories in several hundred subcategories on ways to position the motor.

Here is the overview of the motor position categories:



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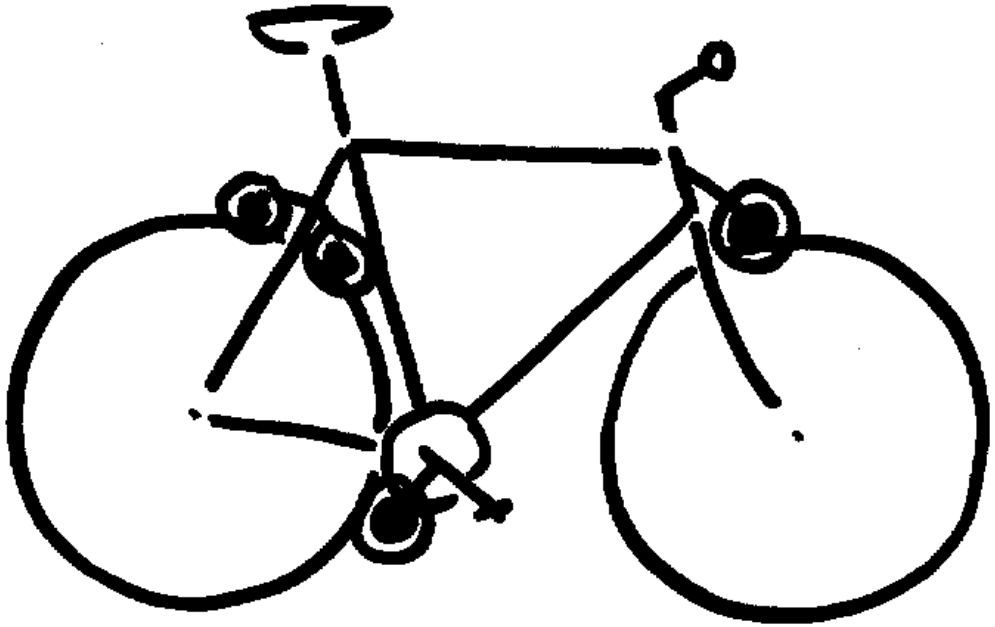
F. 10 Categories of Placing the Motor

1- A +D: Friction Drive on the Tire Surface

+ very simple to produce especially if the roller wheel has the same axle as the motor
+ in good weather conditions, good efficiency
+ especially good for add-on kits
- difficult on dirty/muddy and/or wet roads and the roller wheel has to be replaced quite often



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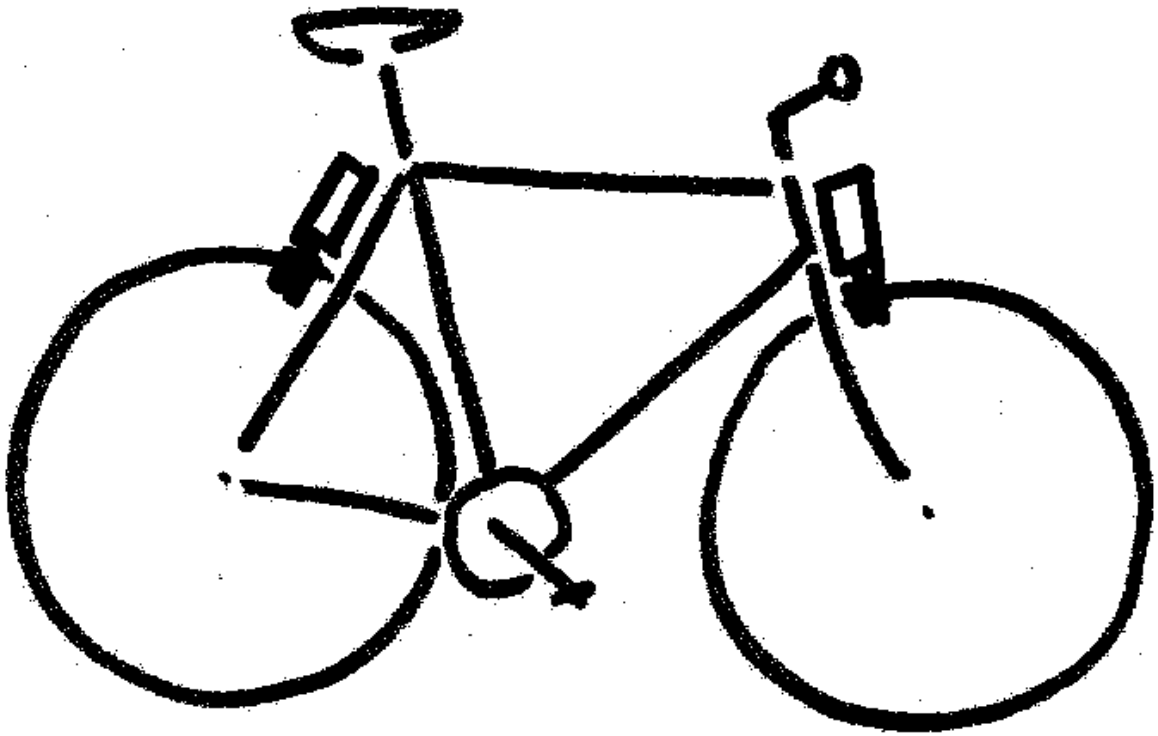
2 - D: Friction Drive on the Side of the Tire

Generally the same as # 1, but better at dirty roads and bad weather conditions



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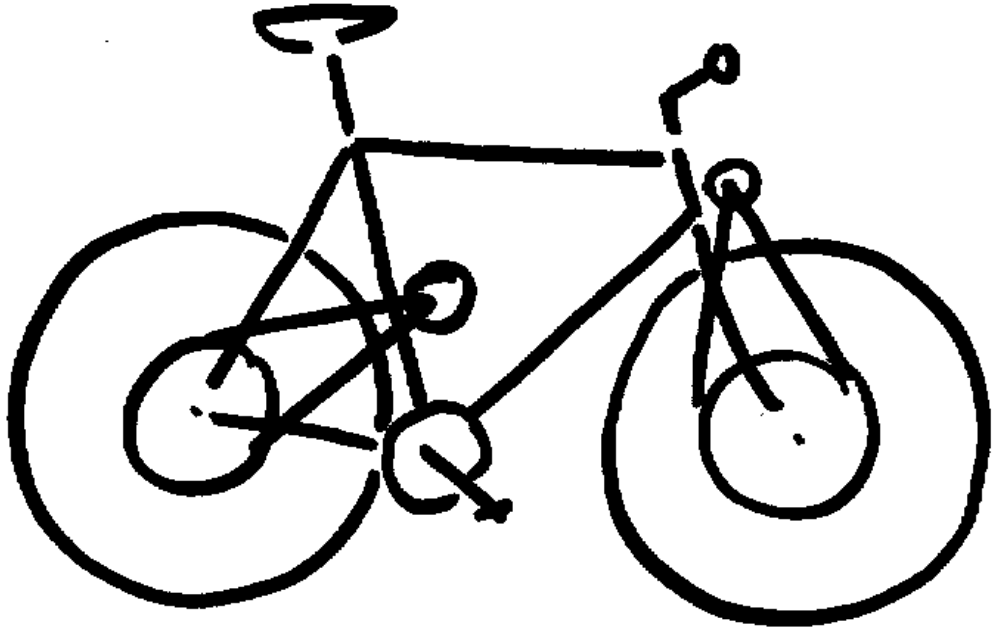
3 - A + D: Direct Drive to One of the Wheels by a Belt, Chain or Other Way of Transmission

+ no interference with the muscle power train
+ usually high efficiency
+ it is easy to disengage the motor by placing a freewheel at the chain ring (or other element) which connects the power train with the wheel
+ with AC drive systems it is easy to produce an effective regenerative brake
- it is usually more difficult to take off the wheel
- with a parallel power train, the risk of a failure is doubled



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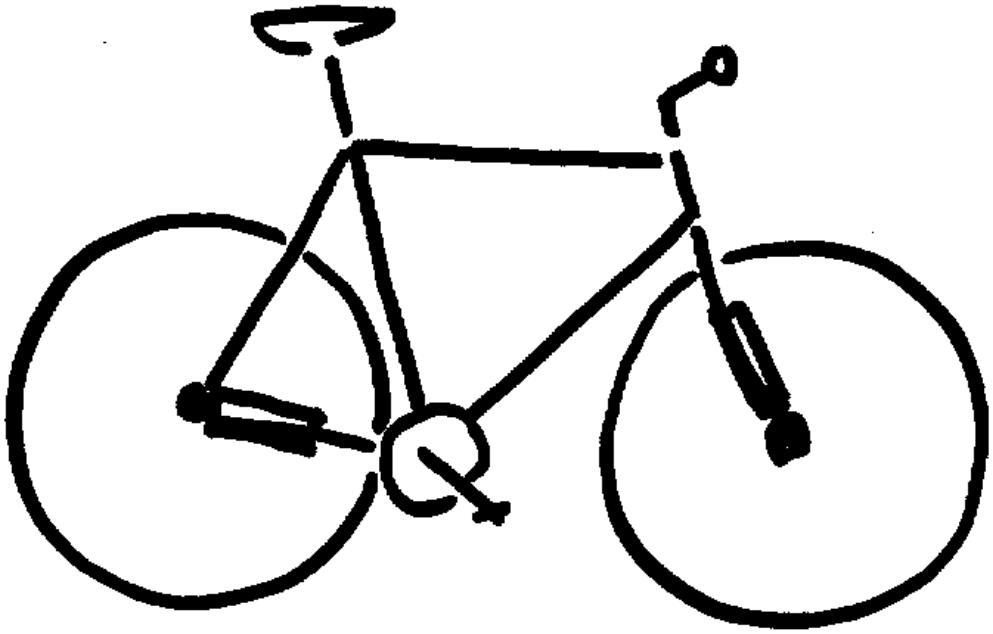
4 - B + C: Motors Direct Drive on the Side of the Hub

+ could make a very compact design if integrated in a single shaft fork at the rear or front wheel.
+ usually high losses in the gearbox
- needs a newly developed axle in order to be useful



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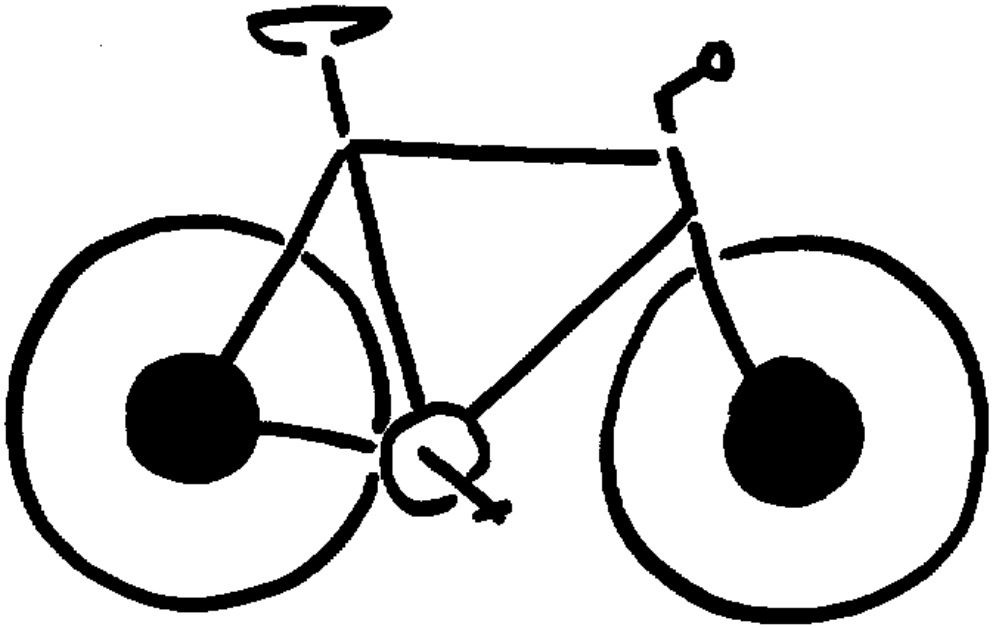
5 - B + C: Hub Motors

+ easy to build into a frame
+ can look very integrated
+ direct drive on both wheels generate many safety features such as ABS and all wheel traction functions for handling difficult road conditions
- if gear less with todays technology, it is not very powerful in the starting position combined with the big wheels
- with gears it is usually too noisy
- if in the front wheel, it can be dangerous on icy roads if the motor control is not very sensitive



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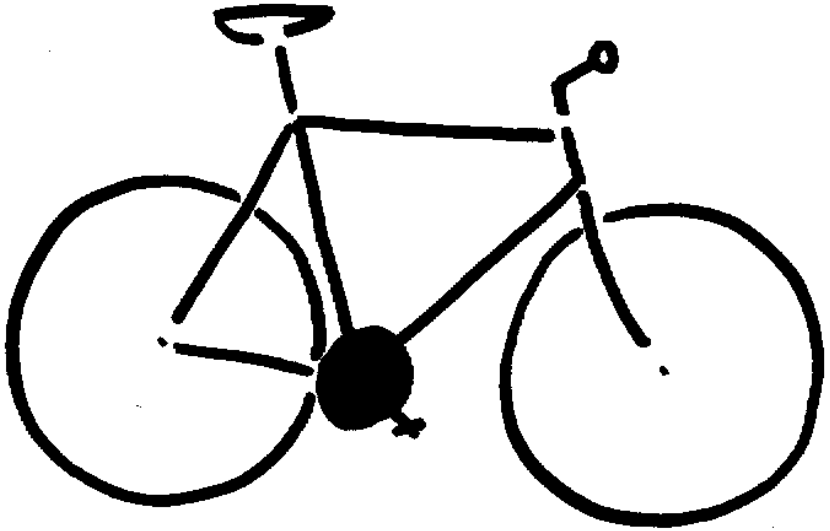
6 - A: Motor in the Pedal Region

(adding power on the muscle power train)

+ does not need a second power train to the wheels
+ makes it easier to adopt the optimum Motor RPM to the pedaling speed because the pedaling speed does not differ so much in the average wheel RPM.
+ positions the motor and gear reduction to the center of gravity
- today in combination with chain gears reduces the life of the chain dramatically because there are not yet chains available that are strong enough
- because it is possible to negotiate a hill without a problem in a low gear, people will take advantage of that, but at the same time, deplete the battery power dramatically. An automatic gear hub like the Shimano Auto D is a combination which make sense.



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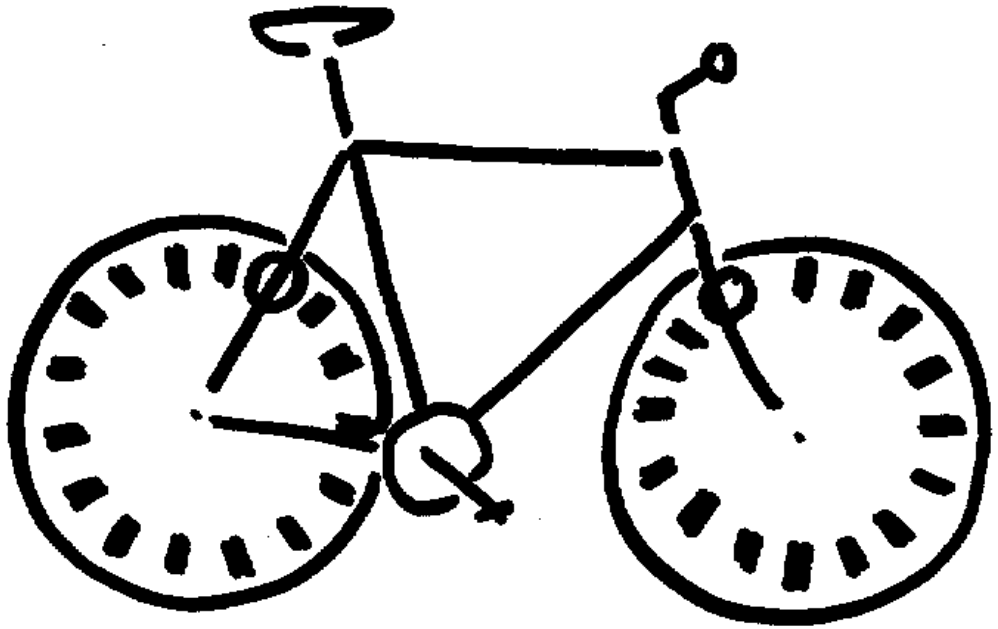
7 - B,C + D: Linear Drive Built into the Rims

+ is extremely cool and a must for technology freaks
- needs very stiff construction of the frame and the wheels
- heavy because of the magnet material in the rim
- could be damaged by metals laying on the road and picked up by the magnets of the rim
- expensive because of the materials and the extra sturdiness of the construction



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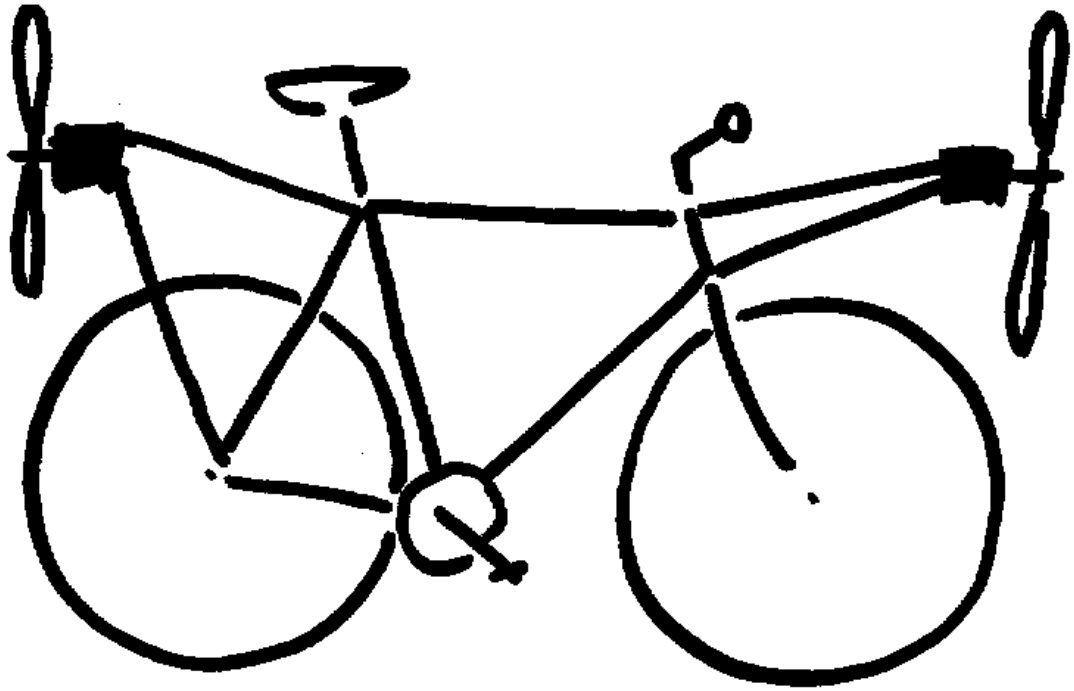
8 - F: Air Pressure or Vacuum

(by propellers, turbines or rocked elements based on the bike)

+ does not interfere with the muscle power train at all
-not practical in downtown areas where you can easily disturb pedestrians by blowing the dust on the road into their eyes



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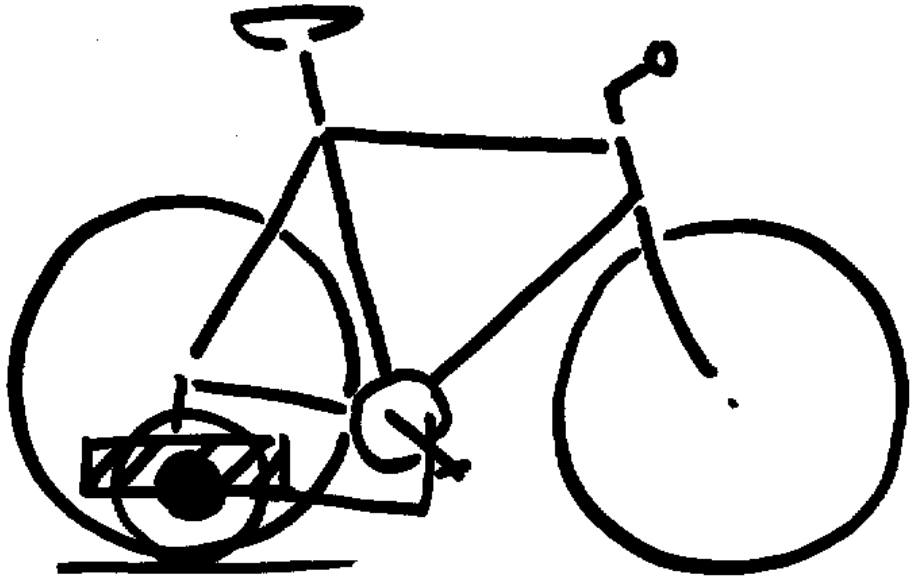
9 - E: Others: Motor in a side wagon

+ easy to put on any bike
- difficult to park bike
- difficult to lift into a car trunk



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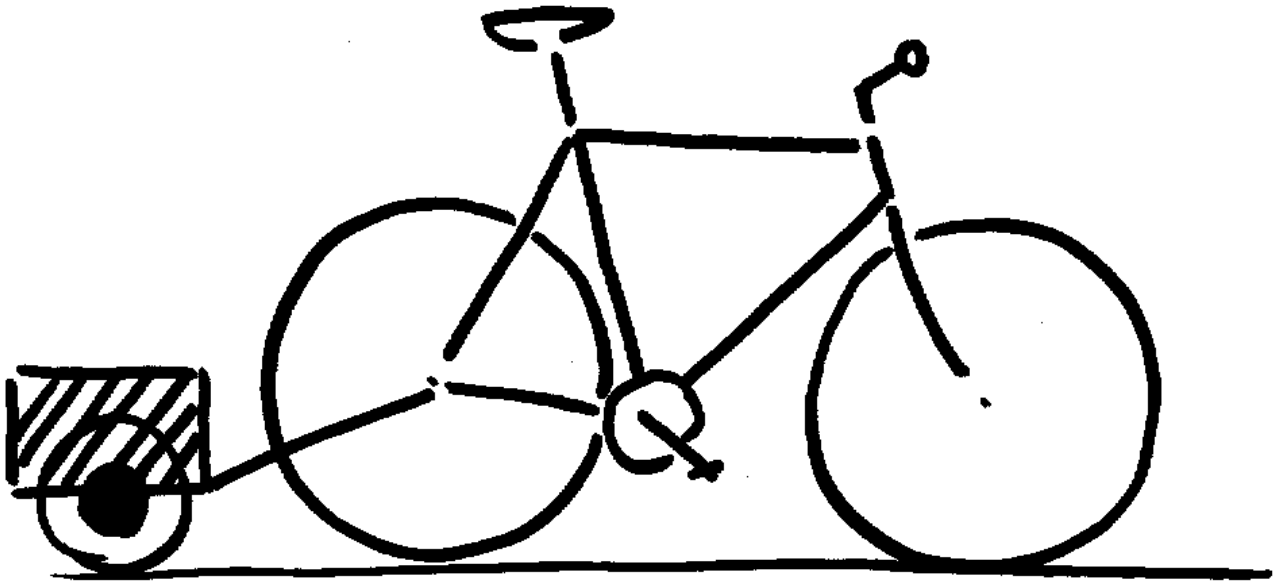
10: Others: Motor in a trailer

+ easy to put on any bike
+ if the whole system (including the motor) is in the trailer and the trailer is just pushing itself and the load, it could be a very good system
- difficult to park bike
- difficult to lift into a car trunk



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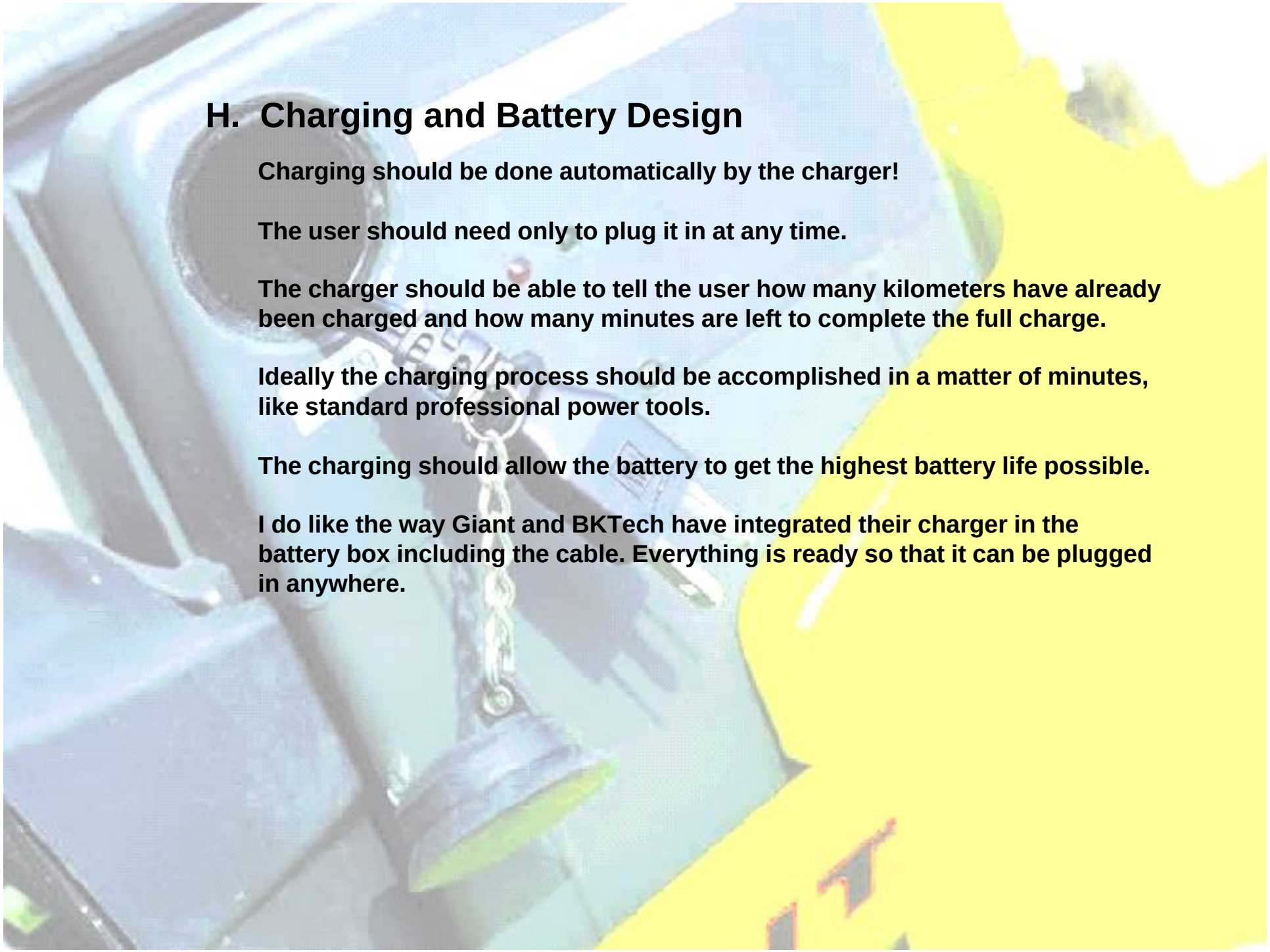

H. Charging and Battery Design

Charging should be done automatically by the charger!

The user should need only to plug it in at any time.

The charger should be able to tell the user how many kilometers have already been charged and how many minutes are left to complete the full charge.

Ideally the charging process should be accomplished in a matter of minutes, like standard professional power tools.

The charging should allow the battery to get the highest battery life possible.

I do like the way Giant and BKTech have integrated their charger in the battery box including the cable. Everything is ready so that it can be plugged in anywhere.

G. Human Interface and Electronic Design

Examples for important functions:

Mileage left in the battery

State of the gear ratio, suggestions how to optimize riding performance

Fuzzy controlled personalization and optimizing of riding

Body health control by checking the riders hearth frequency and combining it with other available data

Safety features like ABS, Airbag...

Anti theft measures like central locking alarm, if unauthorized use is identified

Personal information system, E.g. combination with GPS, mobile web, mobile phone...

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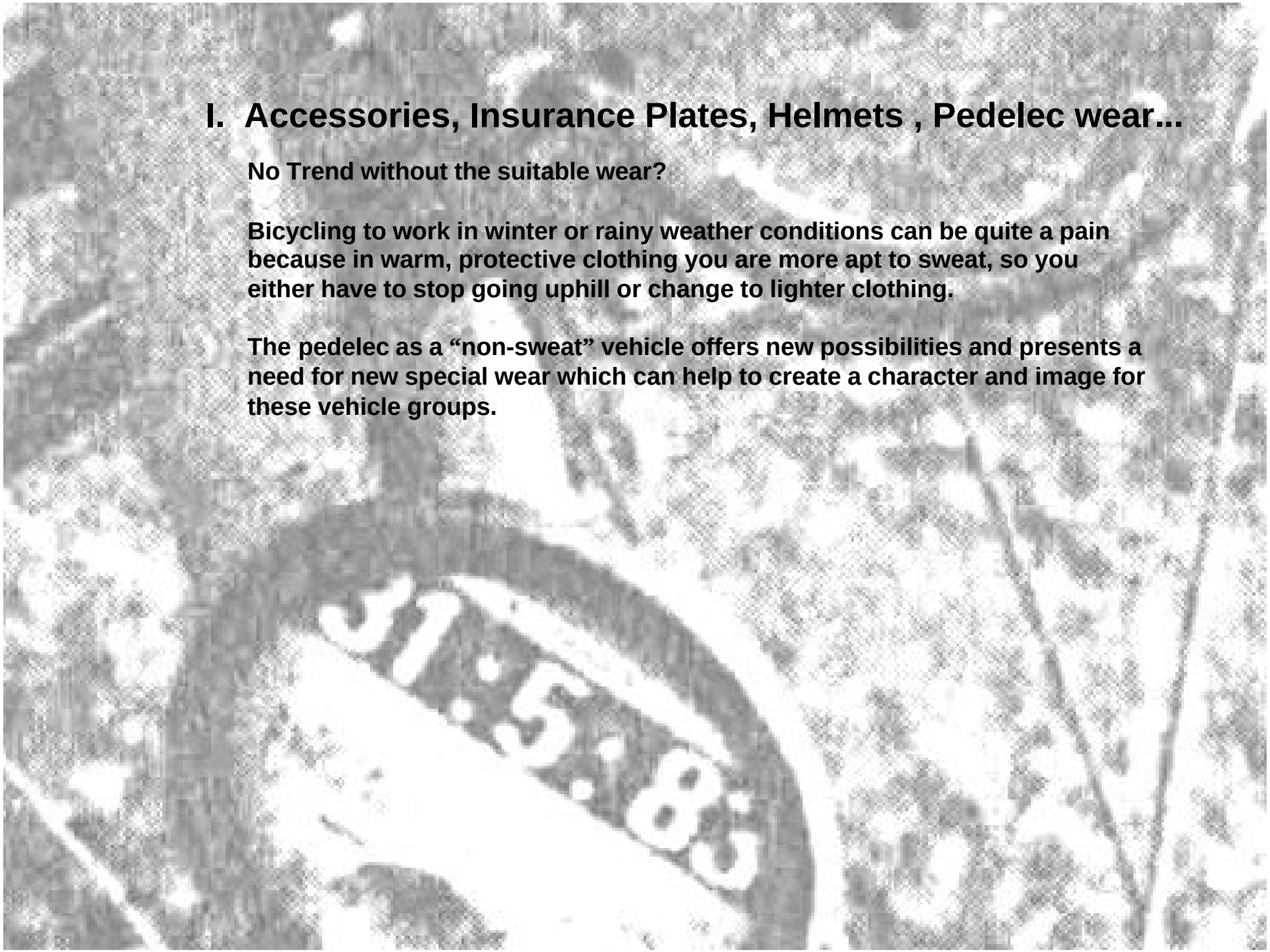
I. Accessories, Insurance Plates, Helmets , Pedelec wear...

No Trend without the suitable wear?

Bicycling to work in winter or rainy weather conditions can be quite a pain because in warm, protective clothing you are more apt to sweat, so you either have to stop going uphill or change to lighter clothing.

The pedelec as a “non-sweat” vehicle offers new possibilities and presents a need for new special wear which can help to create a character and image for these vehicle groups.



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Conclusions:

For successful Pedelec and E-Bike products in the future, the following is a suggested To Do List :

Focus on development of modular components which can be used on a variety of platforms to meet different customer group requirements.

Continuous design improvements are needed to provide expanded market opportunities.

Market research is needed for product design and development decisions.

Expand product test ride demonstrations worldwide to increase the awareness of the public for these products.

Establish a Pedelec / e-Bike academy to teach bike dealers marketing / technical skills.

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General Activities:

Theme Exhibitions for Bicycle Trade Shows
Theme Exhibitions for Electric Utility Companies and Shopping Malls
Public Try-Out Tracks
Product Tests / Market overviews
International Trade Symposiums
Dealer Training
Web Theme Platform for Information and Communication
Dealer Search Engines
Consultation for Companies and Local Authorities

Key Themes for 2001:

Kick-off Presentation of a 4 year and 4,5 Million Euro project focused on market research and key market development in Hannover (Germany), Brescia (Italy) and Barcelona (Spain)

Dealer training in cooperation with key manufacturers and component suppliers

Establishing a Dealer Web-Based Search Engine

Key themes for 2002:

International Pedelec and E-Bike Test